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California Regional PM_{10} and $PM_{2.5}$ Air Quality Study (CRPAQS)
Data Analysis Task 1.1c

COMPARISON AND DESCRIPTIVE EVALUATION OF THE AIRBORNE AND GROUND-BASED MEASUREMENTS COLLECTED DURING THE CCOS FIELD EXPERIMENT

TECHNICAL MEMORANDUM
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1. INTRODUCTION

Airborne measurements of meteorological data and the concentration of various chemical species can be used to develop vertical profiles of atmospheric conditions. These profiles can then be analyzed to establish boundary and initial conditions for photochemical air quality models, as well as to evaluate the performance of these models. Additionally, airborne measurements can be compared to surface measurements to help researchers understand the extent to which data collected at the surface represents the mixed layer above the monitoring site.

As a part of the overall Task 1.1 effort for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS), STI analyzed and evaluated the airborne and ground-based measurements collected during the Central California Ozone Study (CCOS) field experiment in order to determine the comparability of these observations.

2. BACKGROUND AND OBJECTIVES

The objective of this work was to compare measurements of ozone (O_3), nitric oxide (NO), total reactive nitrogen (NO_y), and particle light scattering (b_{sp}) collected in the San Joaquin Valley (SJV) during the summer of 2000 from surface sites and the two STI aircraft operated during the Central California Ozone Study (CCOS). The questions we sought to answer included:

- What is the comparability and equivalence among collocated sampling methods?
- What are the biases of one instrument with respect to others?
- How can these biases be minimized?

Direct intercomparisons between the measurements of identical species in ambient air was made possible by carefully selecting time periods wherein the two systems (airborne and surface) should have been sampling the same air mass. This included the wing-tip flight intercomparisons between the various aircraft involved in CCOS as well as the low altitude passes near surface sites made by several aircraft throughout CCOS. The in-flight aircraft measurement intercomparisons showed excellent agreement and are presented elsewhere (Buhr et al., 2001). Examination of these data was performed to reveal any systematic biases for one or the other platform. The resulting information will be very useful during subsequent interpretation of the data.

3. TECHNICAL APPROACH

The airborne data presented here was collected during 21 sampling missions flown from Bakersfield from July-September, 2000 (Buhr et al., 2001). During the missions, vertical profiles were regularly conducted over 10 locations in the SJV. Of those locations, 7 were either over or near surface monitoring sites, shown on the map in **Figure 3-1**. A total of 88 vertical profiles were conducted over the course of the sampling missions.

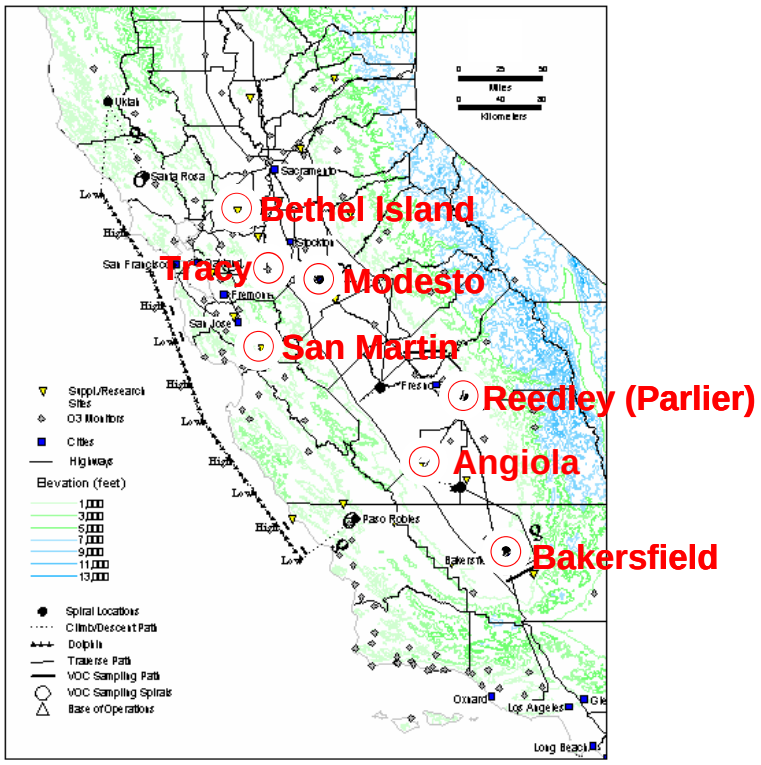

Figure 3-1. Map showing locations of the vertical profiles used for the surface-to-aloft comparisons in the SJV.

The common set of observations between the two STI aircraft and the core ground sites (Bakersfield, Fresno, Angiola) included ozone, NO, NO_y, b_{sp}, temperature, relative humidity (RH), and winds. We focused our comparisons on measurements of ozone, NO, NO_y, and b_{sp}.

We selected aircraft vertical profiles that came within 100 m of the surface and within 10 km of a surface air monitoring site (Blumenthal et al., 1997), then averaged the pollutant data from the bottom 25 m of each spiral. These averages were subsequently compared to the corresponding 1-hr average of data from the nearby surface station centered on the time the vertical profile was developed. These comparisons between the aloft and surface data served to both extend our understanding of the pollutant distribution throughout the mixed layer over the SJV and to assess the comparability of measurements for several ground sites on a given day.

4. RESULTS AND DISCUSSION

Average vertical profiles for each monitoring site were developed from aloft data for morning and afternoon hours. The average profiles shown in **Figures 4-1 through 4-4** show that the gradients near the surface in the morning hours were typically too steep to result in meaningful comparisons. Therefore, only results from afternoon samples when the boundary layer was relatively well mixed were used for subsequent comparisons between surface and aloft data.

The results from afternoon comparisons between surface and aloft data are summarized in **Table 4-1** and displayed in **Figure 4-5** as scatter plots of the comparable species at each of the sites analyzed. Ozone and b_{sp} both show generally excellent correlation between the aloft and surface measurements. NO and to a lesser extent NO_y do not compare as well. This probably results from the high reactivity and steep concentration gradients of these species from the surface into the mixed layer.

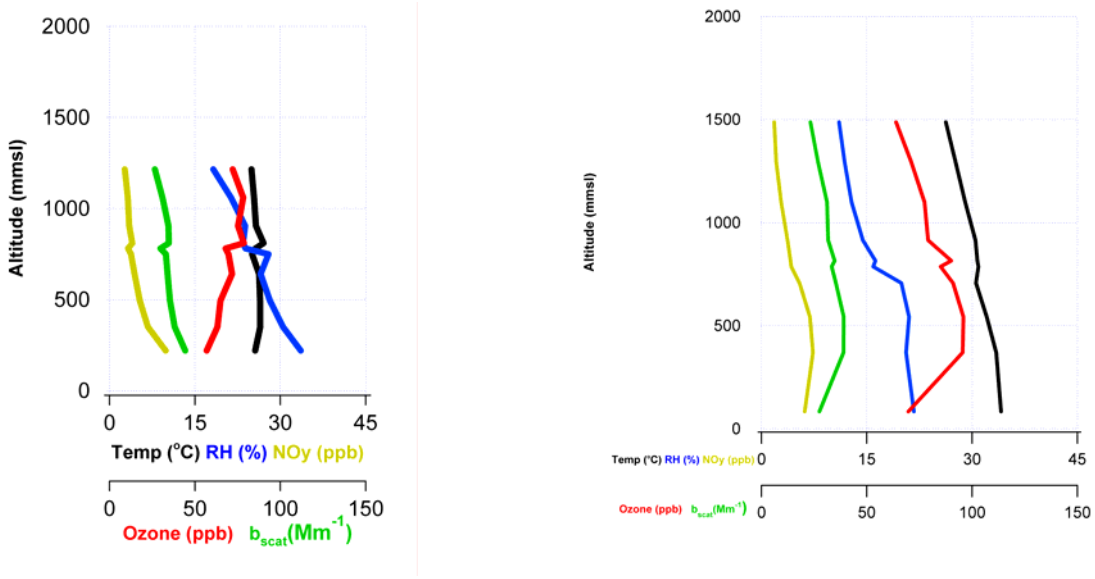

Figure 4-1. Average morning (left) and afternoon (right) vertical profiles for the Angiola monitoring site.

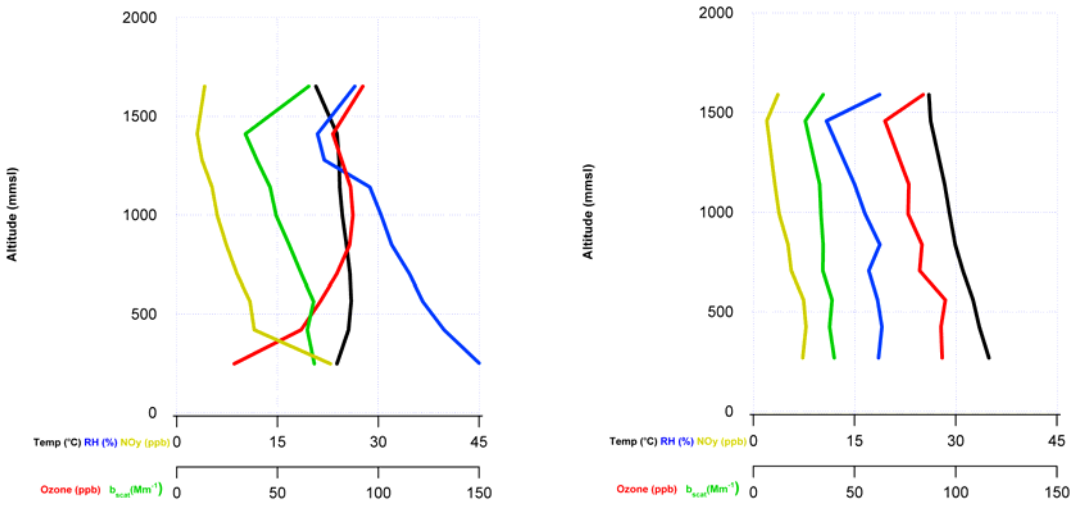

Figure 4-2. Average morning (left) and afternoon (right) vertical profiles for the Bakersfield monitoring site.

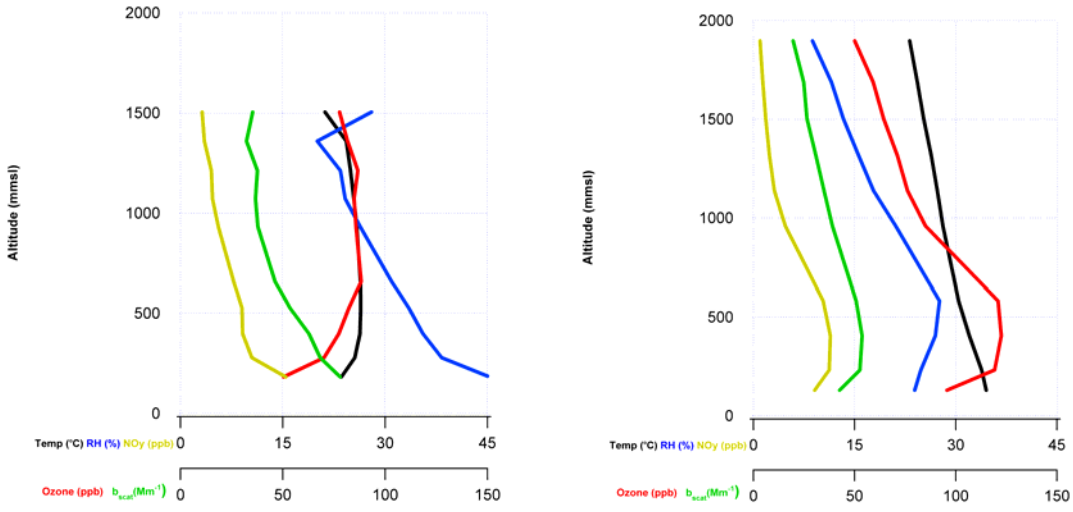

Figure 4-3. Average morning (left) and afternoon (right) vertical profiles for the Reedley monitoring site.

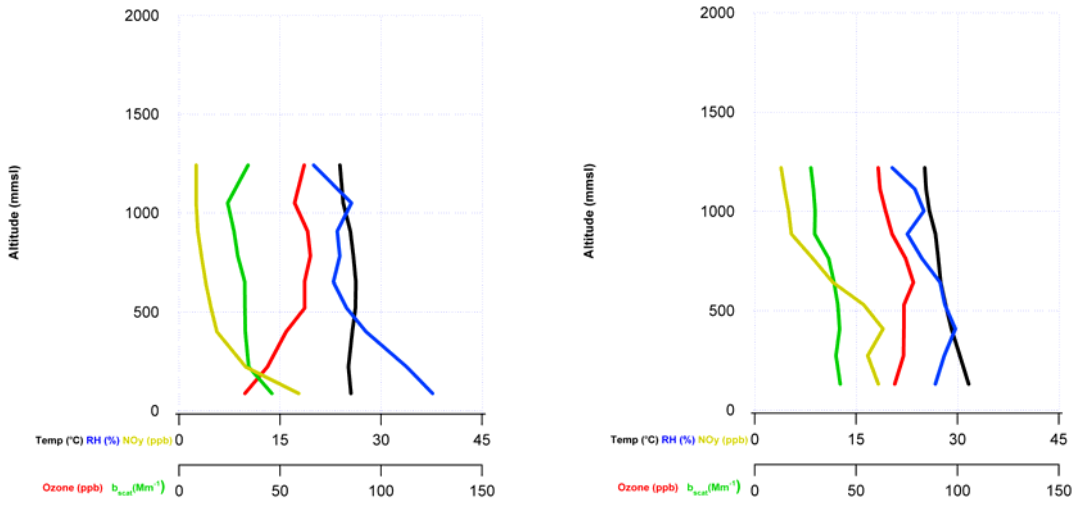

Figure 4-4. Average morning (left) and afternoon (right) vertical profiles for the Modesto monitoring site.

Table 4-1. Results of the afternoon surface to aloft comparisons.

Field Site	Number of Observations	Ozone		NOy		NO		b_{sp}	
		Slope	r^2	Slope	r^2	Slope	r^2	Slope	r^2
Angiola	8	1.078	0.986	0.965	0.940	0.181	0.190	1.067	0.946
Bakersfield	8	1.204	0.887	0.730	0.799	0.145	0.087	0.951	0.968
Bethel Isl.	5	0.975	0.825	0.685	0.761	0.093	0.005	1.301	0.977
Modesto	7	1.067	0.976	N/A	N/A	1.016	0.876	N/A	N/A
Parlier	10	0.979	0.858	1.005	0.968	0.122	0.286	N/A	N/A
Tracy	5	1.104	0.887	N/A	N/A	0.375	0.170	N/A	N/A
San Martin	5	N/A	N/A	1.405	0.496	1.699	0.217	N/A	N/A

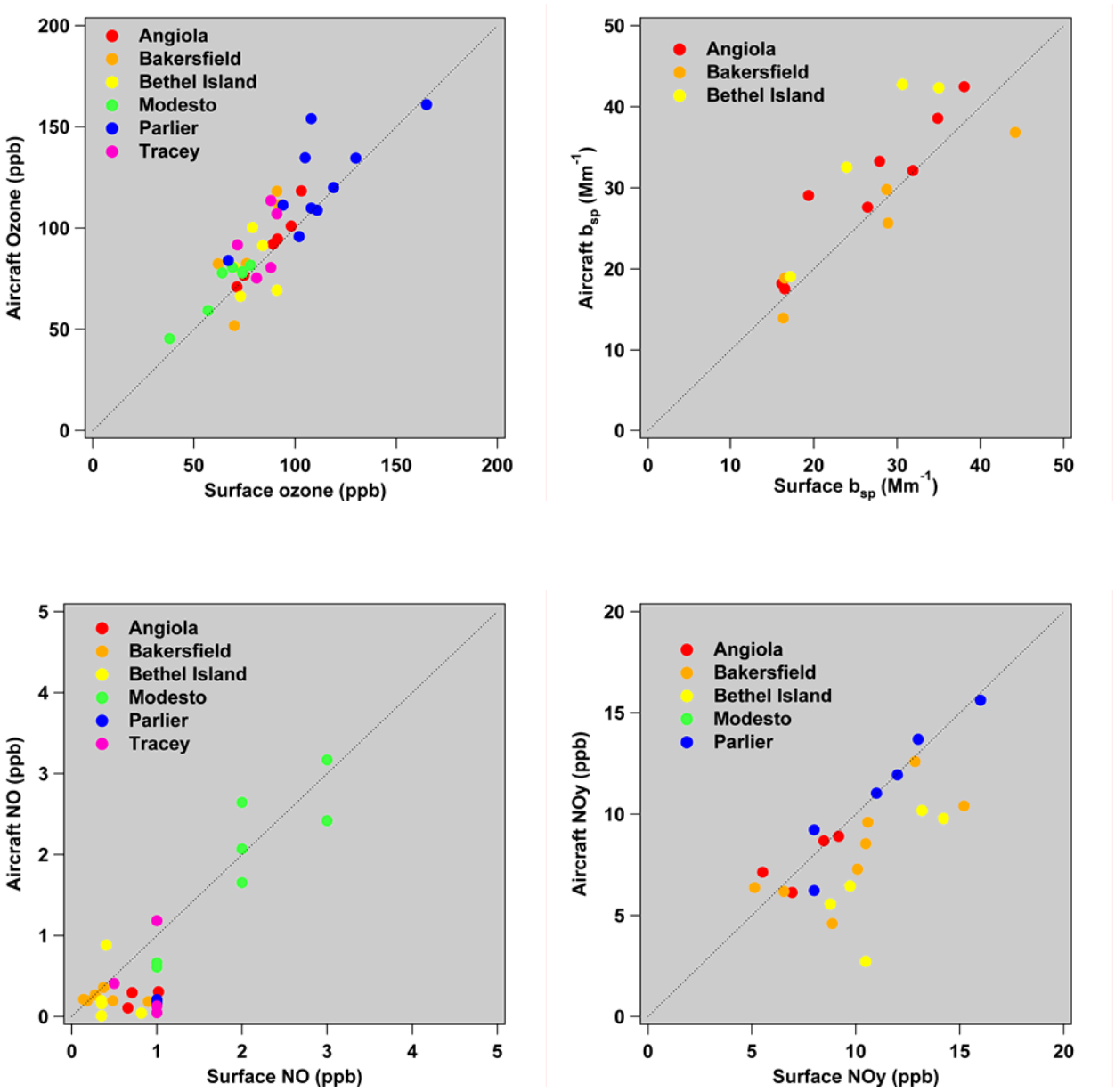

Figure 4-5. Comparison of the average aloft versus surface measurements by monitoring site (afternoon data only). The results from the San Martin site are not included on the graphs.

5. SUMMARY OF FINDINGS

The findings from this analysis can be summarized as follows:

- Agreement between the aloft and surface ozone and light scattering measurements was excellent. The largest difference was seen in the ozone comparison at Bakersfield, because the Bakersfield surface site was located closer to significant sources of NO than the spiral location, resulting in titration of ambient ozone at the surface site.
- The agreement found between the aloft and surface NO and NO_y was poor to moderate, respectively. This is not surprising given the reactivity of these species. The only site with very poor correlation for both NO and NO_y was the San Martin site. In terms of systematic bias, the San Martin site was the only surface site that presented a significantly different relationship with the aloft data than the other surface sites.
- The vertical profiles performed regularly throughout the CRPAQS summer season can serve to extend our understanding of the pollutant distribution in the SJV. In particular, the comparisons highlighted the fact that there are concentration gradients from the surface into the mixed layer that favor secondary products aloft (ozone and light scattering particles as examples) and primary species (NO as an example) near the surface. Aside from the understanding that there are gradients from the surface to the aloft atmosphere it is significant to note that each of the CRPAQS surface sites can be understood as both representative of a broader region and that the surface sites are consistent in measurement accuracy with respect to the aircraft-based systems.

6. REFERENCES

Blumenthal D.L., Lurmann F.W., Roberts P.T., Main H.H., MacDonald C.P., Knuth W.R., and Niccum E.M. (1997) Three-dimensional distribution and transport analyses for SJVAQS/AUSPEX. Final report, STI-91060-1705-FR, February.

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